

Week 4

JPL Snow Server

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NASA Jet Propulsion Laboratory
California Institute of Technology

ARSET

Appplied **R**emote **SE**nsing **T**raining

A project of NASA Applied Sciences



Outline:

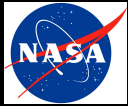
Introduction to the Snow Data System

- 1 Data Sets and Functionality
- 2 Near Real Time and Historical MODIS Snow Cover and Size processing systems
- 3 Near Real Time and Historical MODIS Dust Radiative Forcing processing systems
- 4 Data Access:
 - Western Energy Balance of Snow (WEBS)
 - SNOWMAP (map overlays)
 - Web-based Distributed Authoring and Versioning (WebDAV)



Objectives

- Understand how we get from raw MODIS surface reflectance products, and LANCE MODIS near real-time (NRT) products to Snow Covered Area and Grain Size, and Dust radiative forcing products
- Understand how to get data from JPL Snow Server
- Understand how to use JPL WEBS and SNOWMAP



Satellites providing Snow Products

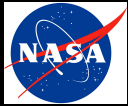
Satellite	Sensors	Quantities
Terra	MODerate Resolution Imaging Spectroradiometer (MODIS) 500 m spatial resolution ~daily temporal resolution	<ul style="list-style-type: none">• Snow covered area• Snow albedo• Snow grain size• Dust/BC radiative forcing
Aqua	MODerate Resolution Imaging Spectroradiometer (MODIS) 500 m spatial resolution ~daily temporal resolution	<ul style="list-style-type: none">• Snow covered area• Snow albedo• Snow grain size• Dust/BC radiative forcing
NPOESS Preparatory Project (NPP) - Suomi	Visible Infrared Imaging Radiometer Suite (VIIRS) 750m spatial resolution ~daily temporal resolution	<ul style="list-style-type: none">• Snow covered area• Snow albedo• Snow grain size• Dust/BC radiative forcing
Landsat Data Continuity Mission (LDCM) (launch February 2013)	Operational Land Imager (OLI) 30 m spatial resolution 16-day temporal resolution	<ul style="list-style-type: none">• Snow covered area• Snow albedo• Snow grain size• Dust/BC radiative forcing



JPL Snow Server

- <http://snow.jpl.nasa.gov>
- Full bore processing and delivery system
 - Near real time and historical processing
 - Dust forcing and snow covered area products
 - Tower data
 - GIS interfaces
 - CSV, JSON, GeoTIFF data format download



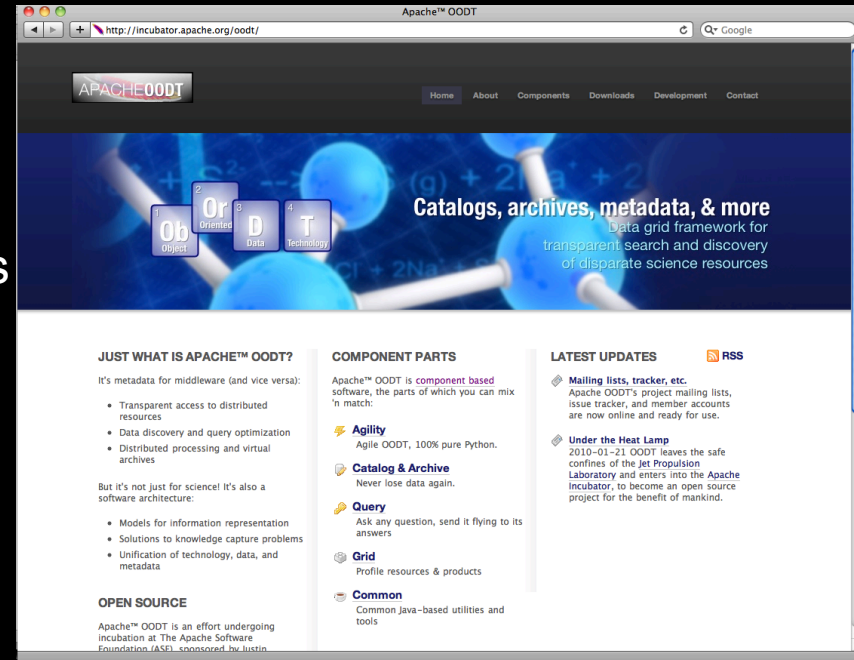


Apache OODT

- Entered “incubation” at the Apache Software Foundation in 2010
- Selected as a top level Apache Software Foundation project in January 2011
- Developed by a community of participants from many companies, universities, and organizations
- Used for a diverse set of science data system activities in planetary science, earth science, radio astronomy, biomedicine, astrophysics, and more



OODT Development & user community includes:

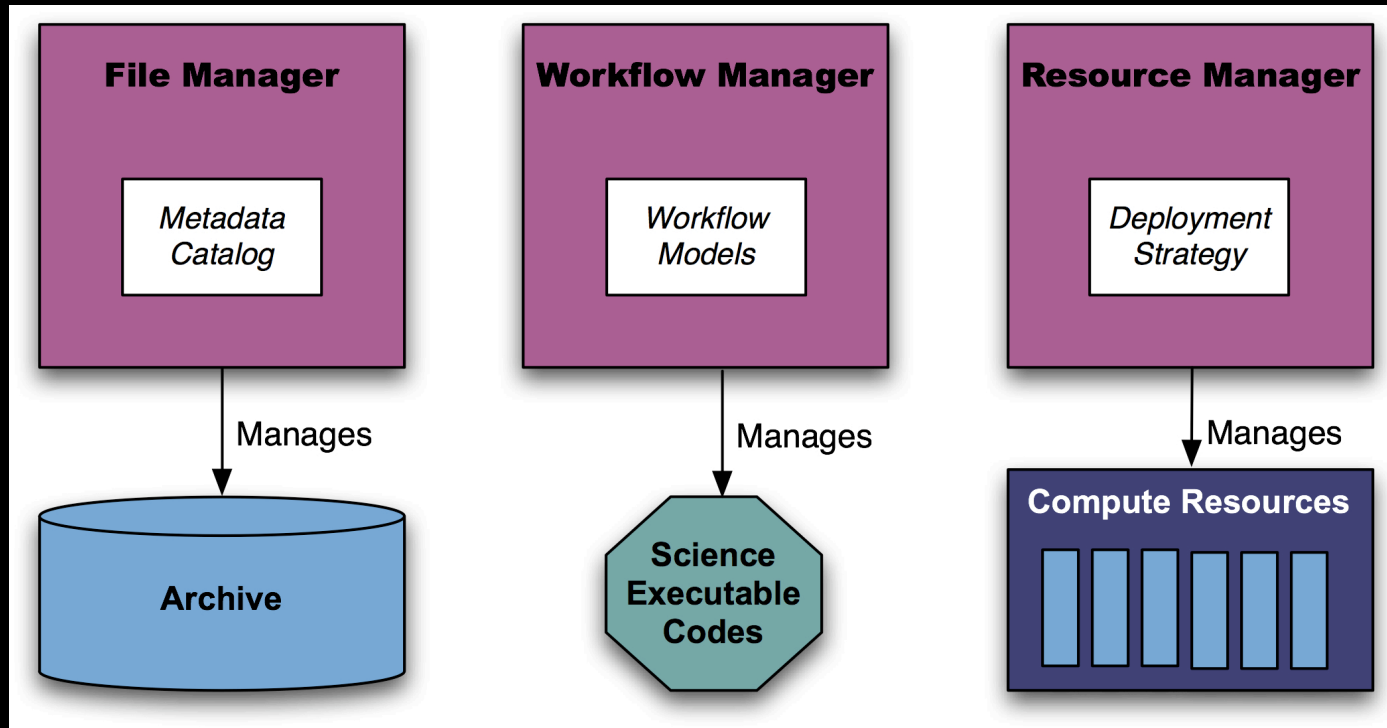


<http://oodt.apache.org>





Apache OODT Core Components



- **All Core components implemented as web services**
 - XML-RPC used to communicate between components
 - Servers implemented in Java
 - Clients implemented in Java, scripts, Python, PHP and web-apps
 - Service configuration implemented in ASCII and XML files



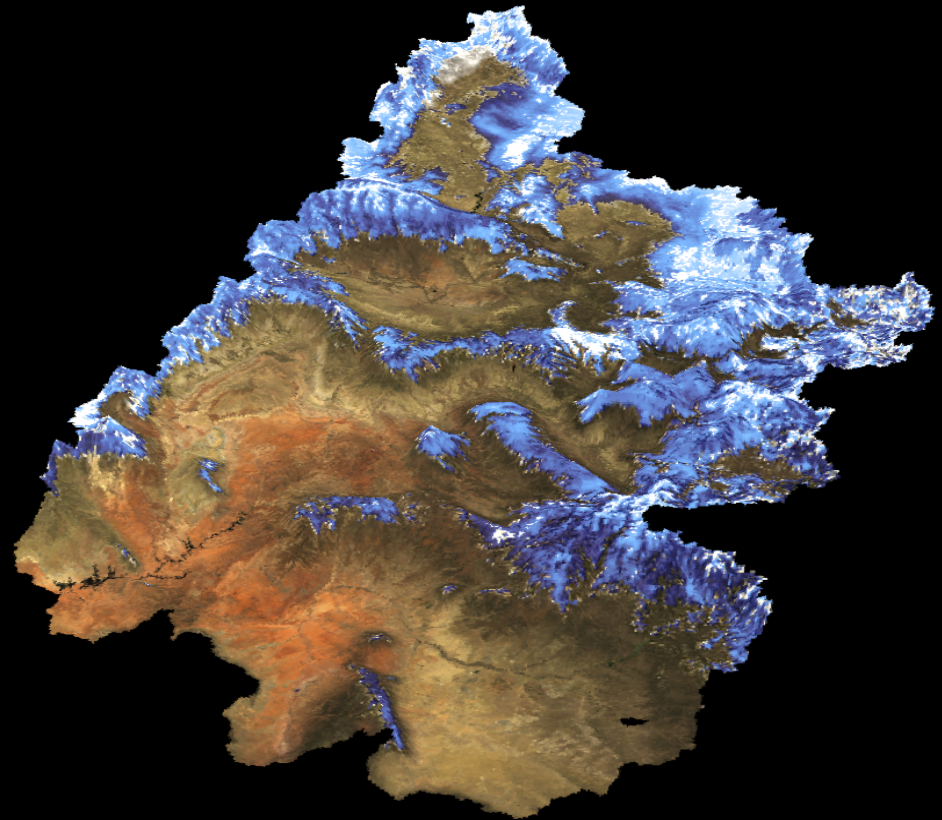
MODIS Snow Covered Area and Grain Size (MODSCAG)

JPL MODSCAG algorithm

(*Painter et al 2009*)

Spectral mixture analysis of
MODIS Surface
Reflectance products

Daily 500 m coverage in
late morning and early
afternoon from NASA
satellites Terra and Aqua

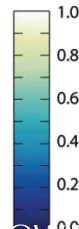


Color Composite

MODSCAG

MOD10A1

Thematic Mapper



7 July, 2006

Upper Colorado River Basin

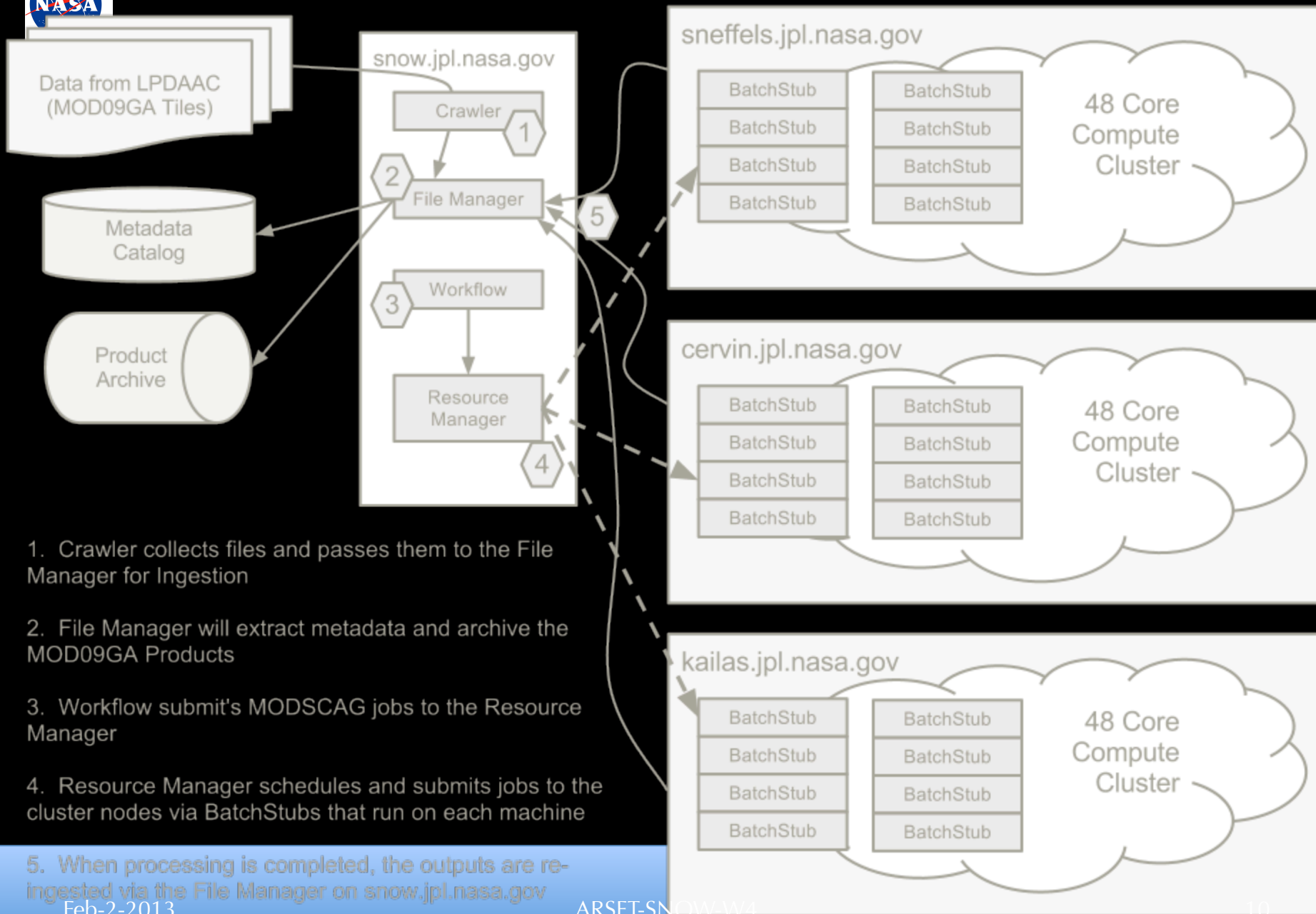
March 9, 2009



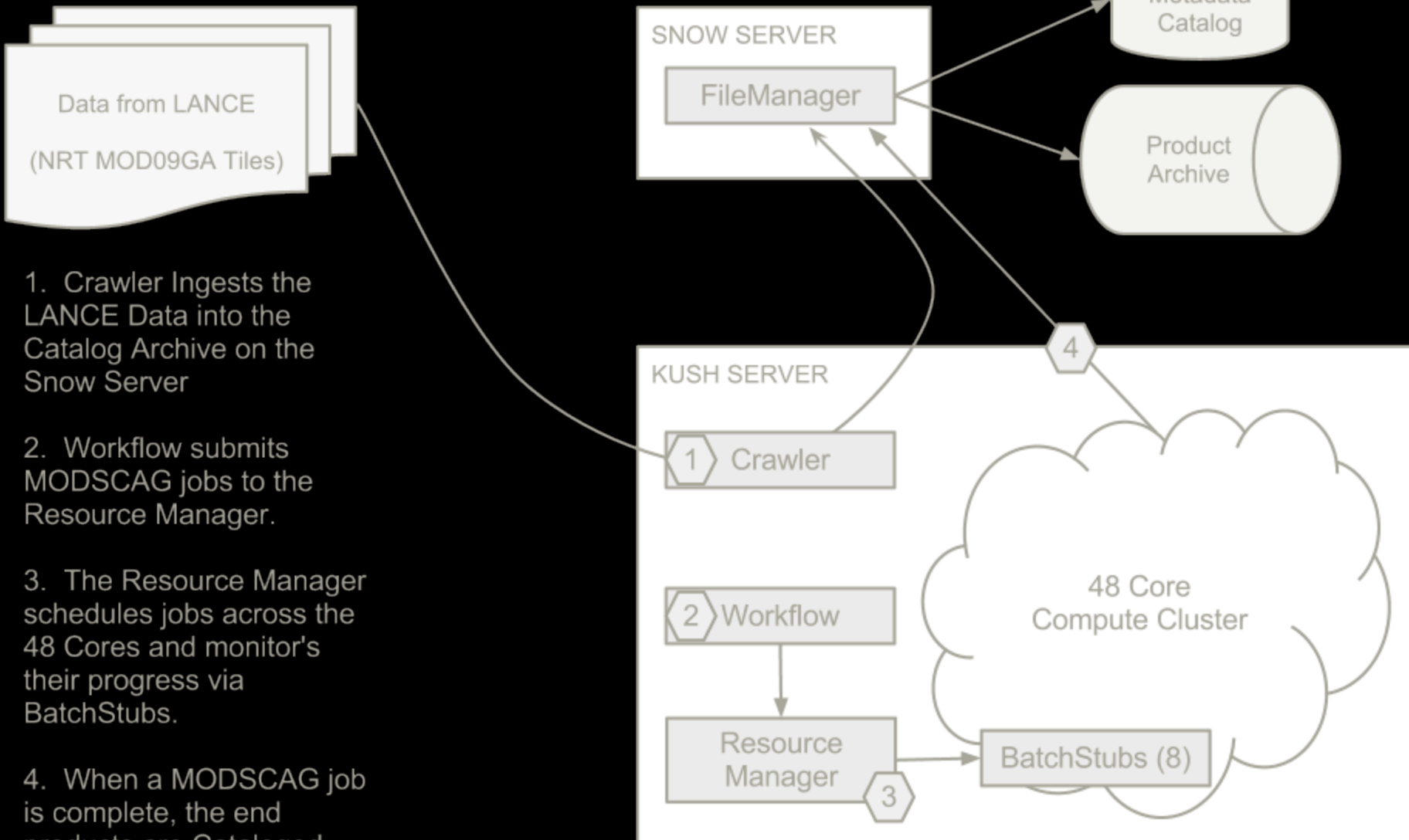
MODSCAG Processing: Two Products/ Two Inputs

- MODIS tiles are defined by their horizontal and vertical tile IDs (the 2 characters after the h and the v respectively)
- Historical Tiles over the Western United States (LPDAAC)
 - Time Range: 2000 - Present
 - h08v04, h08v05, h09v05, h09v04, h10v04
 - LPDAAC is NASA Land Processes data center located at the USGS Earth Resources Observation and Science (EROS) Center in Sioux Falls, South Dakota
- MODIS Near Real-Time Products (LANCE MODIS NRT)
 - Time Range: Dec 2011 - Present
 - Western United States
 - High Asia

MODSCAG Historical Data Processing (144 Cores)



MODSCAG Near Real-Time Process Flow (48 Cores)



4. When a MODSCAG job is complete, the end products are Cataloged and Archived by the Snow Server

Feb-2-2013

ARSET-SNOW-W4

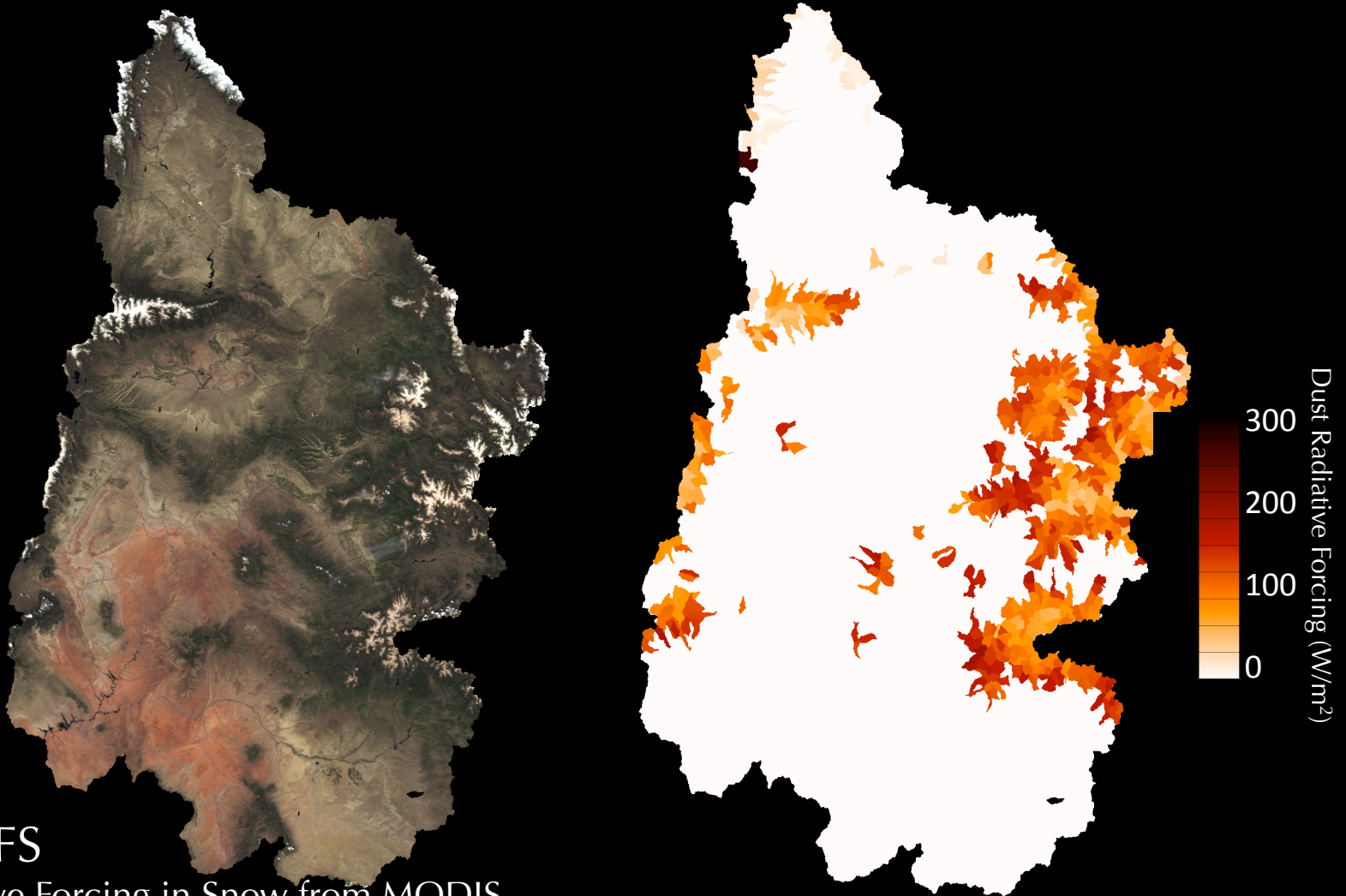
MODT Components

Data Storage

11



Dust Radiative Forcing



MODDRFS

Dust Radiative Forcing in Snow from MODIS

Painter and Bryant, 2012

ARSET-SNOW-W4

17 May 2009



Dust Radiative Forcing Processing

Obtain MOD09GA Surface Reflectance Tiles for the Upper Colorado River Basin (h08v05, h09v04, h09v05, h10v05).



MODSCAG/MOD-DRFS file preparation: HDF extraction of surface reflectance bands, cloud properties, solar and sensor geometry.



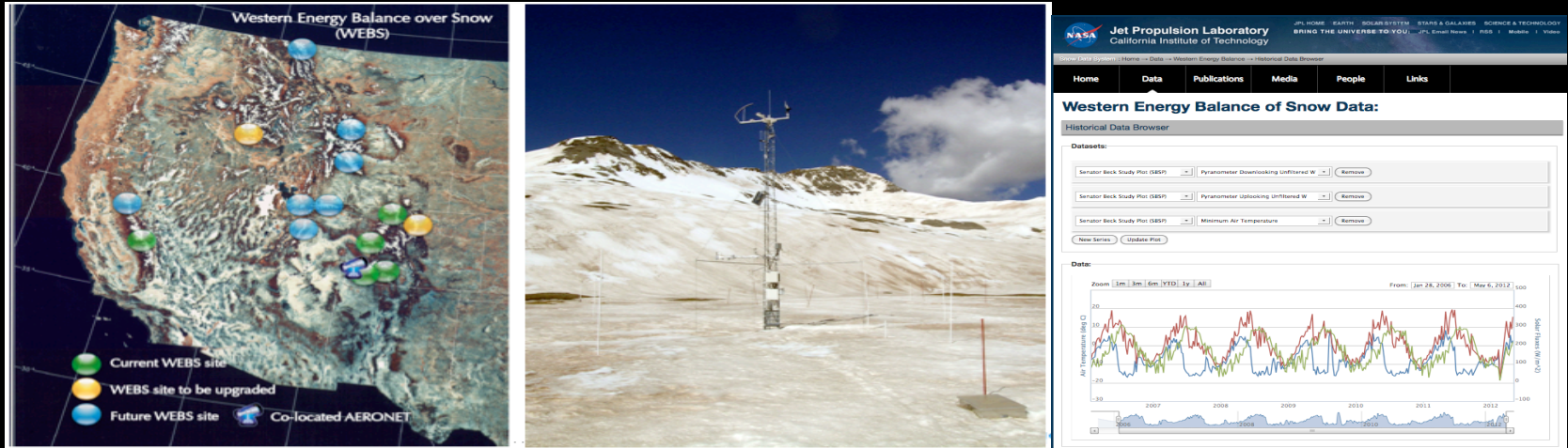
MOD-DRFS algorithm computes radiative forcing by dust on snow.



MODSCAG/MOD-DRFS post-processing: cloud masking and de-striping



Dr. Tom Painter's Western Energy Balance of Snow (WEBS) Tower Network

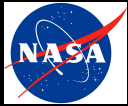


- Network of heavily instrumented towers in snow-covered regions to facilitate modeling of the energy balance and melt of the snow cover, and dust/BC radiative forcing in the snow cover.
- Standard measurements of meteorology (air temperature, wind speed, relative humidity, all at two heights), also incident and reflected broadband solar radiation and incident and reflected near infrared/shortwave infrared solar radiation



Western Energy Balance of Snow

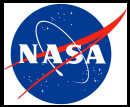
- Western Energy Balance of Snow (WEBS)
 - Historical And Near-Real-Time Access
- Towers deployed in several key snow areas
- Connect to towers and pull down data actively



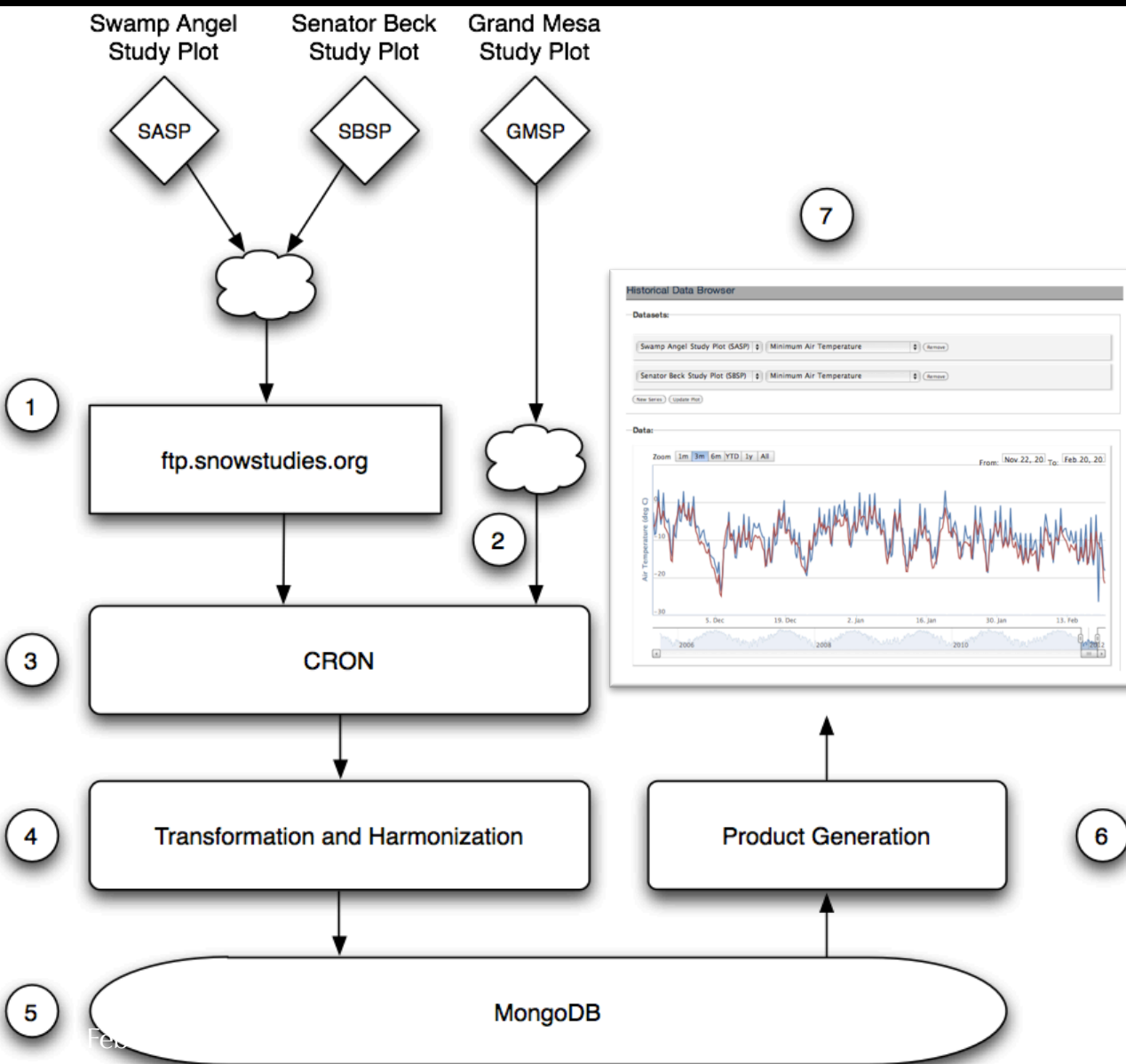
WEBS Data Processing

<http://snow.jpl.nasa.gov/portal/data/webs>

- Historical data:
 - Swamp Angel Study Plot: WY 2006 – Present
 - Senator Beck Study Plot: WY 2006 – Present
 - Grand Mesa Study Plot: WY 2009 – Present
- Near-real-time collection:
 - Automated hourly refresh rate
- Data Access
 - Interactive browser-based visualization
 - Customizable data product download



WEBS Data Collection Architecture



1) Data from SASP and SBSP staged to <ftp.snowstudies.org>

2) Data from GMSP obtained by direct connection to the tower

3) A Cron job pulls down the latest hourly data

4) Data from all stations is homogenized and cleaned

5) Data is stored in MongoDB for fast, scalable querying

6) Data is selectively extracted and formatted as needed for data delivery

7) Users interact with, and request, data via a browser-based interface.



WEBS Browser Interface

<http://snow.jpl.nasa.gov/portal/data/webs>

- Access to tower-specific information
- Access to the full range of historical data

The screenshot shows the Jet Propulsion Laboratory (JPL) website header with the NASA logo and the text "Jet Propulsion Laboratory California Institute of Technology". Navigation links include "JPL HOME", "EARTH", "SOLAR SYSTEM", "STARS & GALAXIES", and "BRING THE UNIVERSE TO YOU: JPL Email". A breadcrumb trail reads "Snow Data System : Home → Data → Western Energy Balance of Snow". Below this is a navigation bar with tabs: "Home", "Data" (which is active), "Publications", "Media", "People", and "Links". The main content area is titled "Data: Western Energy Balance of Snow". It contains a short description of the Western Energy Balance of Snow product and its relevance to the Snow Data System efforts, with a link to the official source. A section titled "Tower Network" lists four study plots: "Swamp Angel Study Plot", "Senator Beck Study Plot", "Grand Mesa Study Plot", and "Mammoth Study Plot". A red oval highlights this list. Below this is a section titled "Historical Data Browser" with a description of the visual data browser and a link to "Enter the Historical Data Browser".

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Snow Data System : Home → Data → Western Energy Balance of Snow

Home Data Publications Media People Links

Data: Western Energy Balance of Snow

Some short description of the Western Energy Balance of Snow product and its relevance to the Snow Data System efforts. Maybe a link to the official source for the project...

Tower Network

The Western Energy Balance of Snow tower network includes the following installations:

- [Swamp Angel Study Plot](#)
- [Senator Beck Study Plot](#)
- [Grand Mesa Study Plot](#)
- [Mammoth Study Plot](#)

Historical Data Browser

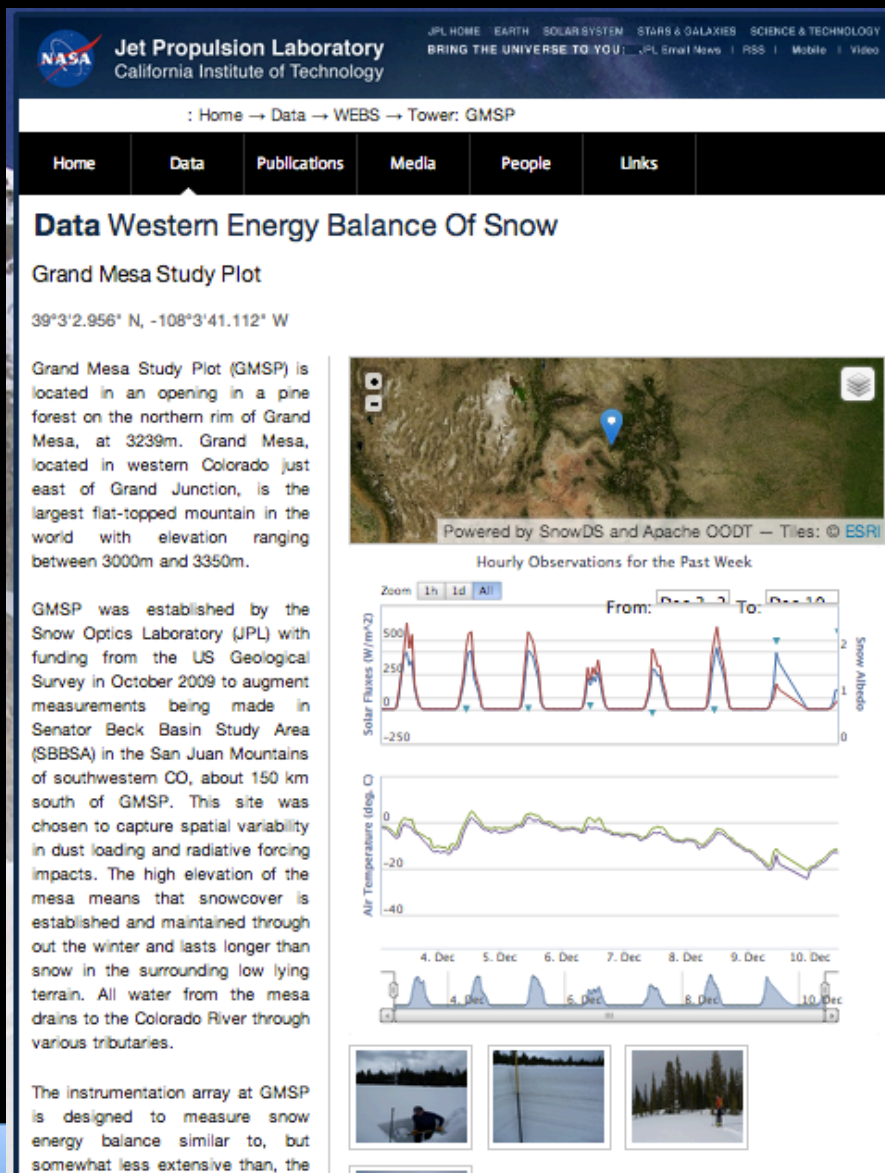
The visual data browser provides a graphical view of hourly measurements at the project. Using the visual data browser it is possible to select and compare measurements from different towers on a sliding time scale.

[Enter the Historical Data Browser](#)



WEBS Browser Interface

- Detailed Tower Information
- Geographical location
- Equipment background
- Latest observational data
- Site Photos
- Data Download via CSV





WEBS Browser Interface

Western Energy Balance of Snow Data:

Historical Data Browser

Datasets:

Dataset 1:

Swamp Angel Study Plot (SASP)

Minimum Air Temperature C

Update

clear series

Dataset 2:

Select Site...

Select Parameter...

Update

clear series

Dataset 3:

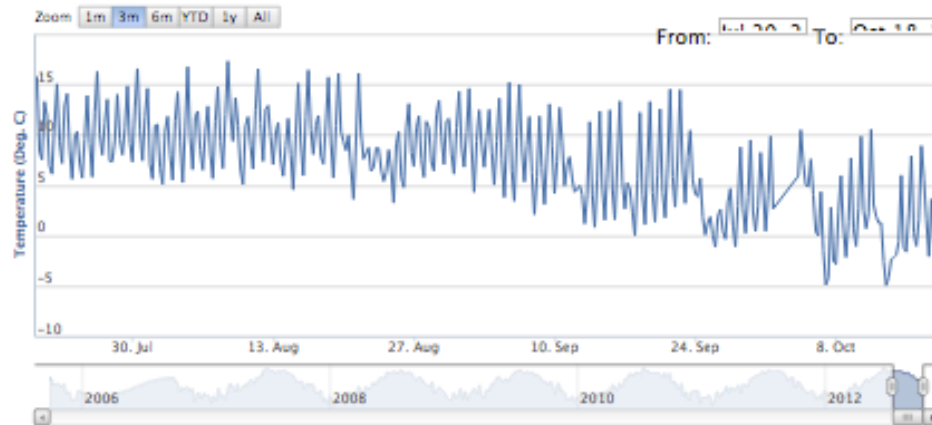
Select Site...

Select Parameter...

Update

clear series

Visualization:



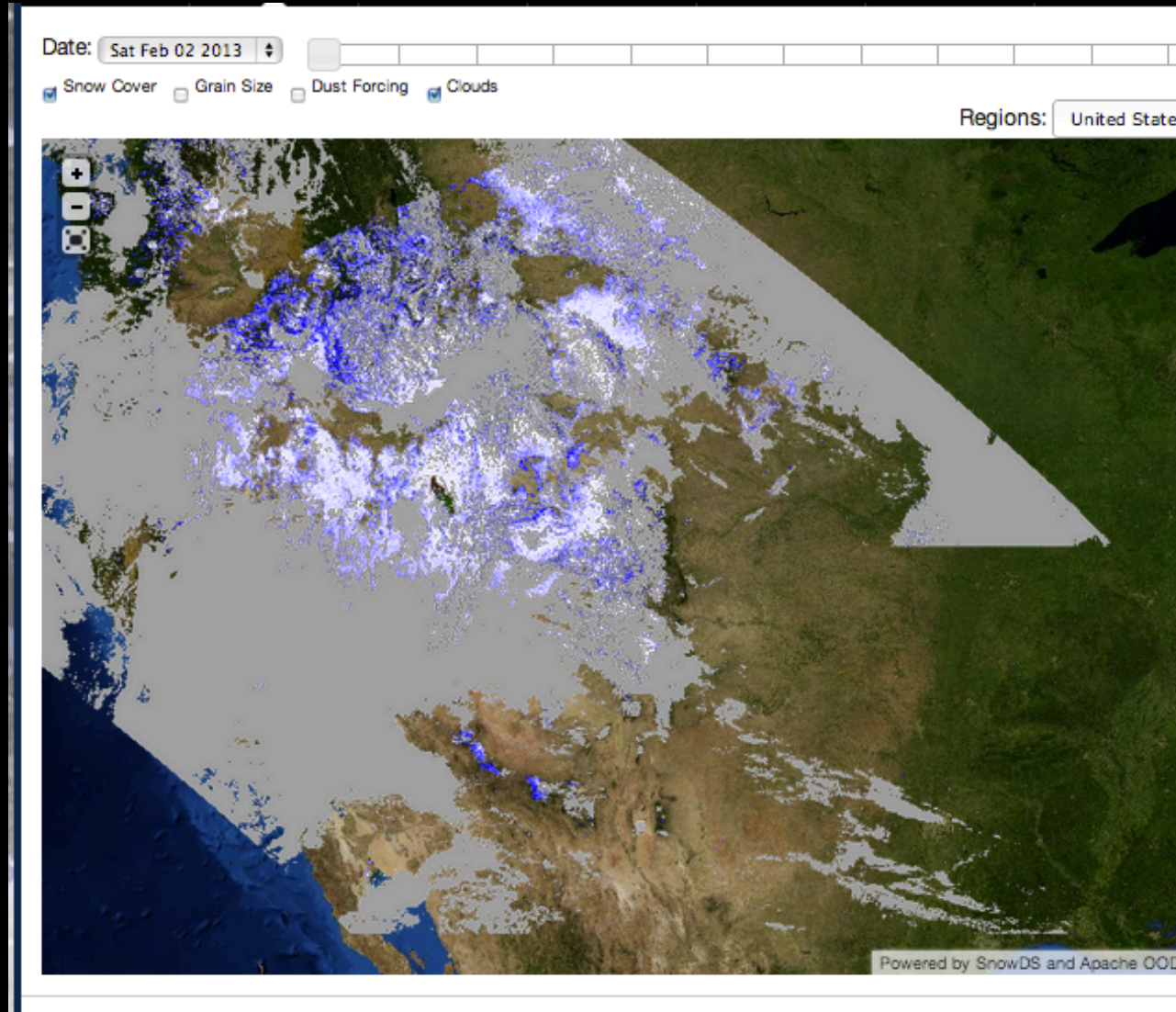
Interactive data visualization

- Select towers
- Select parameters
- Select date ranges
- Select download format as CSV, JSON, etc.



SNOWMAP– <http://snow.jpl.nasa.gov/portal/data/map>

- Showing snow covered area layer and clouds
- Products available as WMS (variety of formats)





Access to Snow Products via GIS

- Use GIS tools (shown in next slides after terminology) to
 - Download Snow datasets as GeoTIFF, Raster
 - Reproject the data into your own coordinate reference systems
 - Browse/interact with the data
 - Store the data in databases like PostGIS and compute distances, geometric functions, etc.



GIS Terminology

- **OGC** - The *Open Geospatial Consortium* is an international consortium of companies, government agencies, and universities participating in a consensus process to develop publicly available geospatial and location-based services. Interfaces and protocols defined by OpenGIS specifications support interoperability and seek to integrate geospatial technologies with wireless and location-based services
- **Raster** - A spatial data model that defines space as an array of equally sized cells arranged in rows and columns, and composed of single or multiple bands. Each cell contains an attribute value and location coordinates. Unlike a vector structure, which stores coordinates explicitly, raster coordinates are contained in the ordering of the matrix. Groups of cells that share the same value represent the same type of geographic feature.
- **Vector** - A coordinate-based data model that represents geographic features as points, lines, and polygons. Each point feature is represented as a single coordinate pair, while line and polygon features are represented as ordered lists of vertices. Attributes are associated with each vector feature, as opposed to a raster data model, which associates attributes with grid cells.
- **KML** - Keyhole Markup Language (KML) is an XML notation for expressing geographic annotation and visualization within Internet-based, two-dimensional maps and three-dimensional Earth browsers. Originally developed by Google for Google Earth and later turned over to the OGC for standardization.

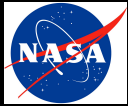
Credit Paul Ramirez 2011-2012



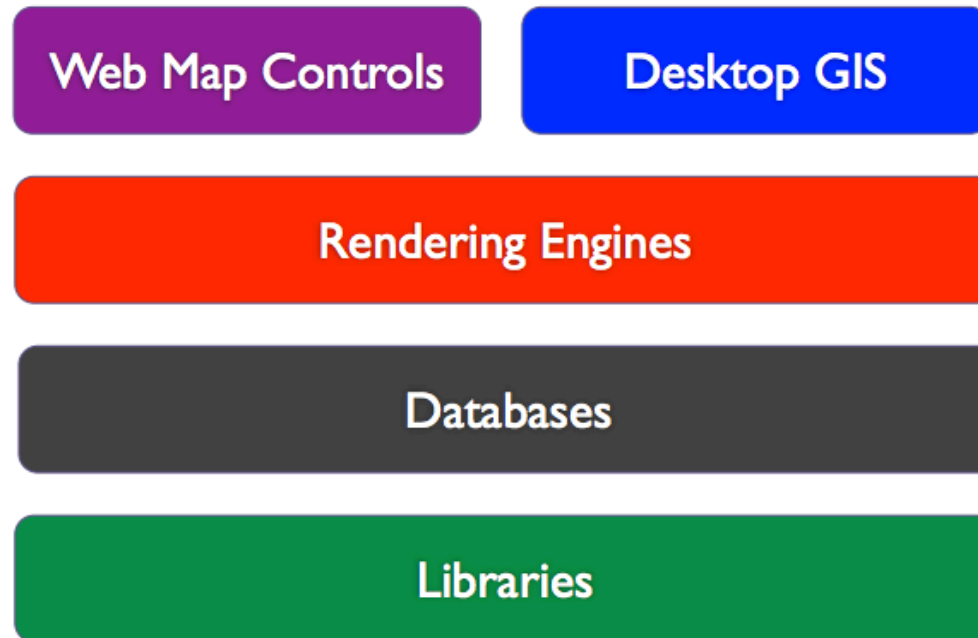
GIS Terminology Con't

- **Map** - A graphic representation of the spatial relationships of entities within an area.
- **WMS** - is a standard protocol for serving georeferenced map images over the Internet that are generated by a map server using data from a GIS database. The specification was developed and first published by the OGC in 1999
- **Feature** - A representation of a real-world object on a map.
- **WFS** - The OGC Web Feature Service Interface Standard (WFS) provides an interface allowing requests for geographical features across the web using platform-independent calls. One can think of geographical features as the "source code" behind a map.
- **Coverage** – Mapping of one aspect of data in space. It represents a “domain” in terms of characteristics expressing a range of values. For example: a satellite image derived from remote sensing might record varying degrees of light pollution. Aerial photography, land cover data, and digital elevation models all provide coverage data.
- **WCS** – The OGC Web Coverage Service (WCS) provides an interface allowing requests for geographical coverages across the web using platform-independent calls.

Credit Paul Ramirez 2011-2012

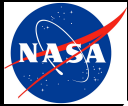


GIS Architecture Stack

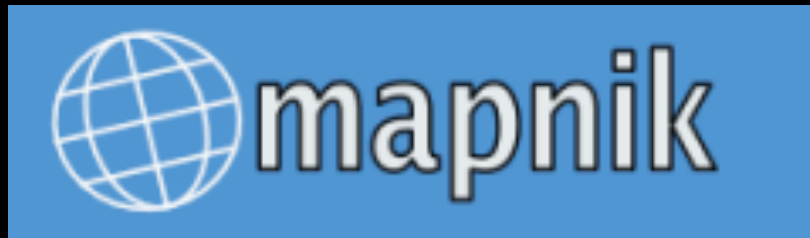


Credit Paul
Ramirez
2011-2012

Source: <http://foss4g-na.org/wp-content/uploads/2012/03/RamseyKeynote.pdf>



GIS tools for JPL Snow Server Data



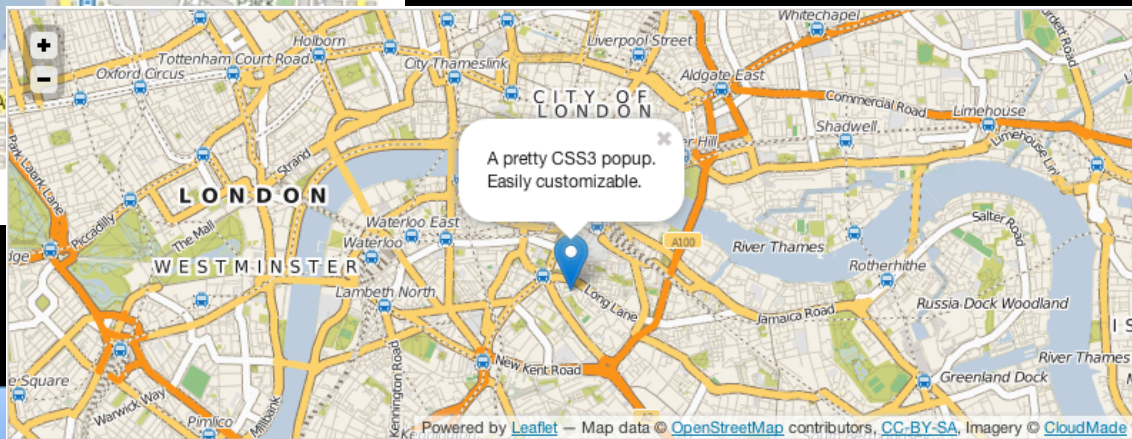
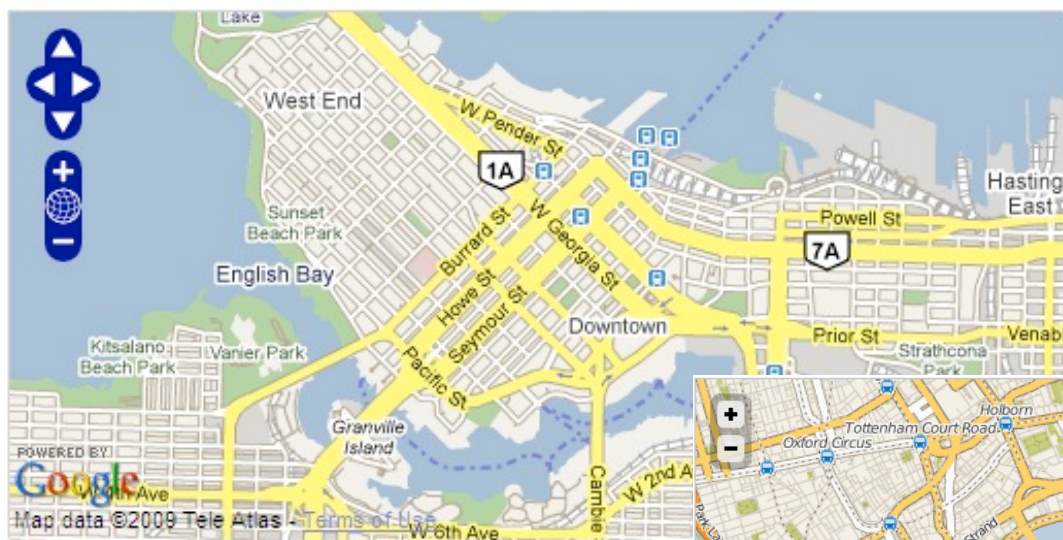
Credit Paul Ramirez 2011-2012



Web Map Controls



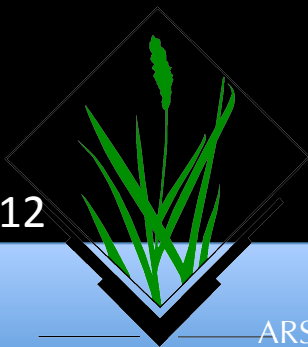
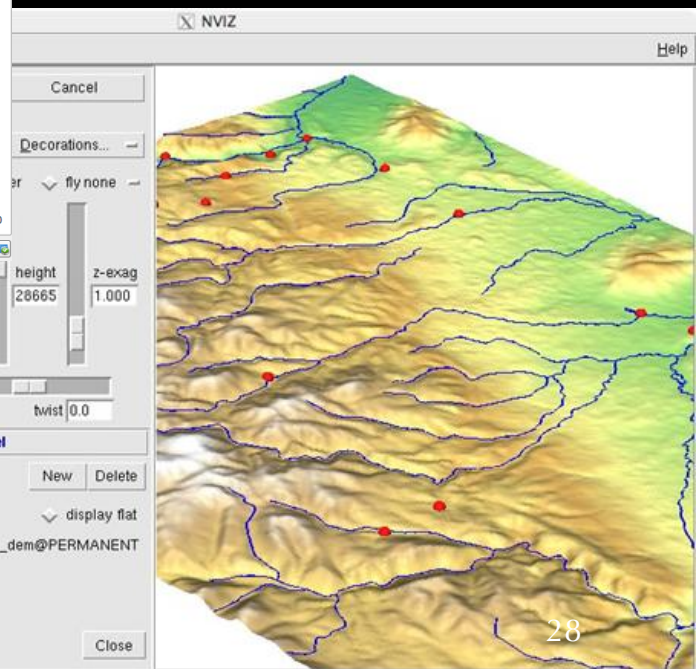
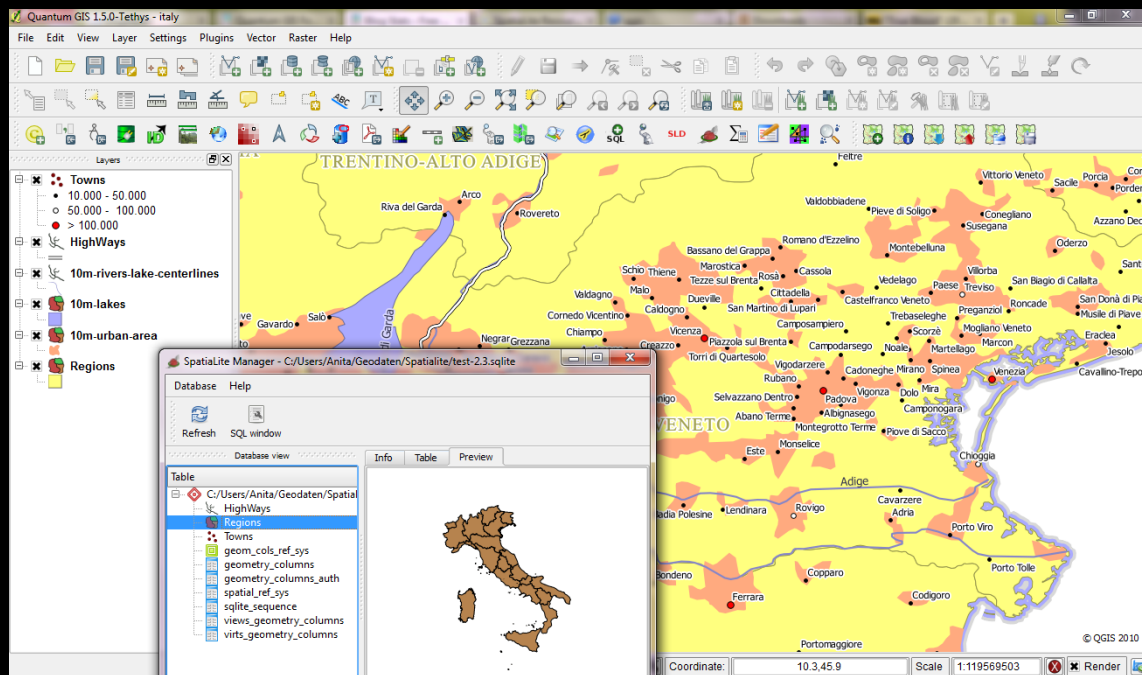
OpenLayers: Google Layer Example



Credit Paul Ramirez 2011-2012



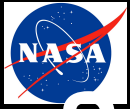
Desktop



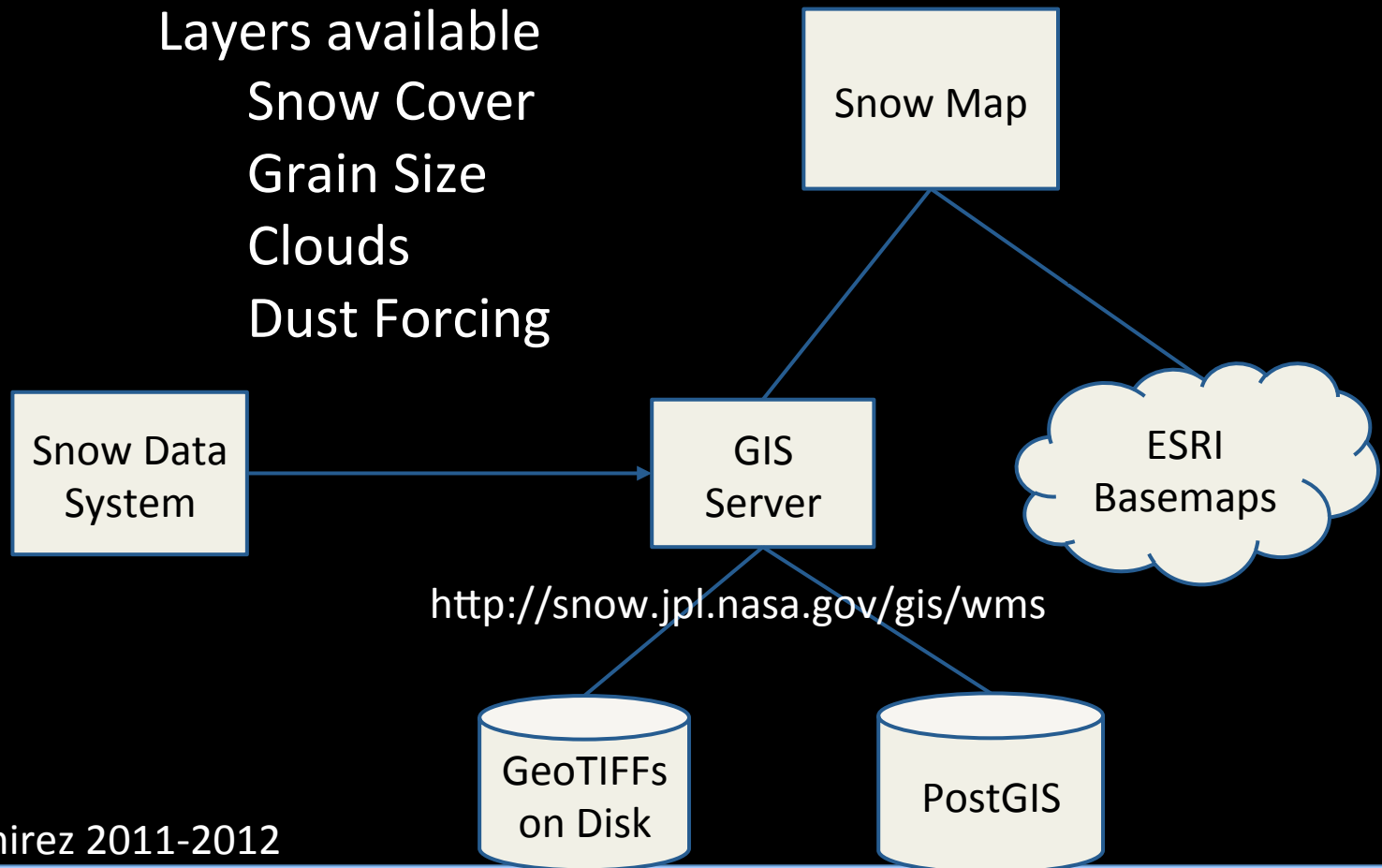
Credit Paul Ramirez 2011-2012

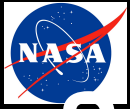
Feb-2-2013

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Snow Map Architecture





Snow Map Detail

Use WMS - <http://snow.jpl.nasa.gov/gis/wms>

Many GIS components support this out of the box.

For instance, Leaflet that we use for our map

Layers exposed via WMS will be timed based

Historical dataset

Lance NRT

Define styles for the data using Styled Layer Descriptor

SLD is a standard and supported by most GIS servers

Easily change styles or support multiple styles per layer

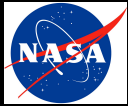
Clients can pick from available styles on a layer

Expose tower based information using WFS

Click on a tower to get a graph

Publish our own basemap if needed

For instance a hillshade or color hillshade on the DEM used during processing



Data Browse and Download

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: Home → Data

Home Data Publications Media People Links

Data

This page provides a single point of entry into the entire repository of data provided by the Snow Data System.

Tips and Hints for Using Snow Data Products

The following page contains important information about understanding the data products available from this site.

Snow Data Product Browser

The Snow Data System product browser provides detailed information and the ability to download raw data products from the Snow Data System archive.

[Access the Data](#)

Snow Map (Experimental)

This experimental map overlays data from multiple remote sensing and in situ sources to provide a comprehensive picture of snow and ice properties.

[Access the Map](#)

Western Energy Balance of Snow (WEBS) Data

View Western Energy Balance of Snow data plotted by station and parameter, and download the raw input data directly.

[Access the Data](#)

Click on data
tab

Click Snow
data product
browser



Data Product Browse/Download

- Select dust forcing (MOD-DRFS) or Snow Covered Area (MODSCAG)

: Home → Browser

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Snow Data System Browser

Surface Reflectance Products

Search:

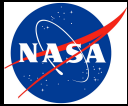
Show 100 entries per page

Name	Description	Id
MOD09GA	The MODIS Surface Reflectance products provide an estimate of the surface spectral reflectance as it would be measured at ground level in the absence of atmospheric scattering or absorption. Low-level data are corrected for atmospheric gases and aerosols, yielding a level-2 basis for several higher-order gridded level-2 (L2G) and level-3 products. MOD09GA provides Bands 1-7 in a daily gridded L2G product in the Sinusoidal projection, including 500-meter reflectance values and 1-kilometer observation and geolocation statistics. 500-m Science Data Sets provided for this product include reflectance for Bands 1-7, a quality rating, observation coverage, observation number, and 250-m scan information. 1-kilometer Science Data Sets provided include number of observations, quality state, sensor angles, solar angles, geolocation flags, and orbit pointers. Version-5 MODIS/Terra Surface Reflectance products are Validated Stage 2, meaning that accuracy has been assessed over a widely distributed set of locations and time periods via several ground-truth and validation efforts. Although there may be later improved versions, these data are ready for use in scientific publications.	urn:snow:MOD09GA
MOD09GANRT	This subset of MODIS Surface Reflectance files have been sourced from the LANCE Near Real Time data repository. They have not been through the same quality control process that the traditional MOD09GA products do.	urn:snow:MOD09GANRT

Showing 1 to 2 of 2 entries

Snow Products

Name	Description	Id
MODDRFS	MODDRFS is short for MODIS Dust Radiative Forcing in Snow. This Product Type is the final output from the Snow Data Management System.	urn:snow:MODDRFS
MODSCAG	MODSCAG is short for MODIS Snow Covered Area and Grain size. This Product Type is the final output from the Snow Data Management System after using the MODSCAG IDL Routines	urn:snow:MODSCAG



Product File Browser

- Select a product
- View received time
- Sorted by received time
 - Latest on top

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: Home → Browser → MOD09GANRT → Products

Home Data Publications Media People Links

MOD09GANRT

Description:

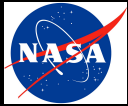
This subset of MODIS Surface Reflectance files have been sourced from the LANCE Near Real Time data repository. They have not been through the same quality control process that the traditional MOD09GA products do.

[Additional Information](#) [Downloadable Files](#)

Downloadable Files for this Dataset


Page 1 of 9 (products 1 - 50) [Next Page >>](#)

Product Name	CAS.ProductId	CAS.ProductReceivedTime
MOD09GA.A2013034.h10v03.005.NRT.hdf	0187eae3-6e80-11e2-a790-879db9e5ae5f	2013-02-03T20:04:43.510-08:00
MOD09GA.A2013034.h11v03.005.NRT.hdf	f8e5d5a2-6e7f-11e2-a790-879db9e5ae5f	2013-02-03T20:04:29.026-08:00
MOD09GA.A2013034.h08v04.005.NRT.hdf	ee254d31-6e7f-11e2-a790-879db9e5ae5f	2013-02-03T20:04:10.988-08:00
MOD09GA.A2013034.h08v05.005.NRT.hdf	e7352db0-6e7f-11e2-a790-879db9e5ae5f	2013-02-03T20:03:59.347-08:00



Per Product Metadata

- View product metadata including upstream pedigree, and processing information

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: Home → Browser → MOD09GANRT → Products → 0187eae3-6e80-11e2-a790-879db9e5ae5f

[Home](#) | [Data](#) | [Publications](#) | [Media](#) | [People](#) | [Links](#)

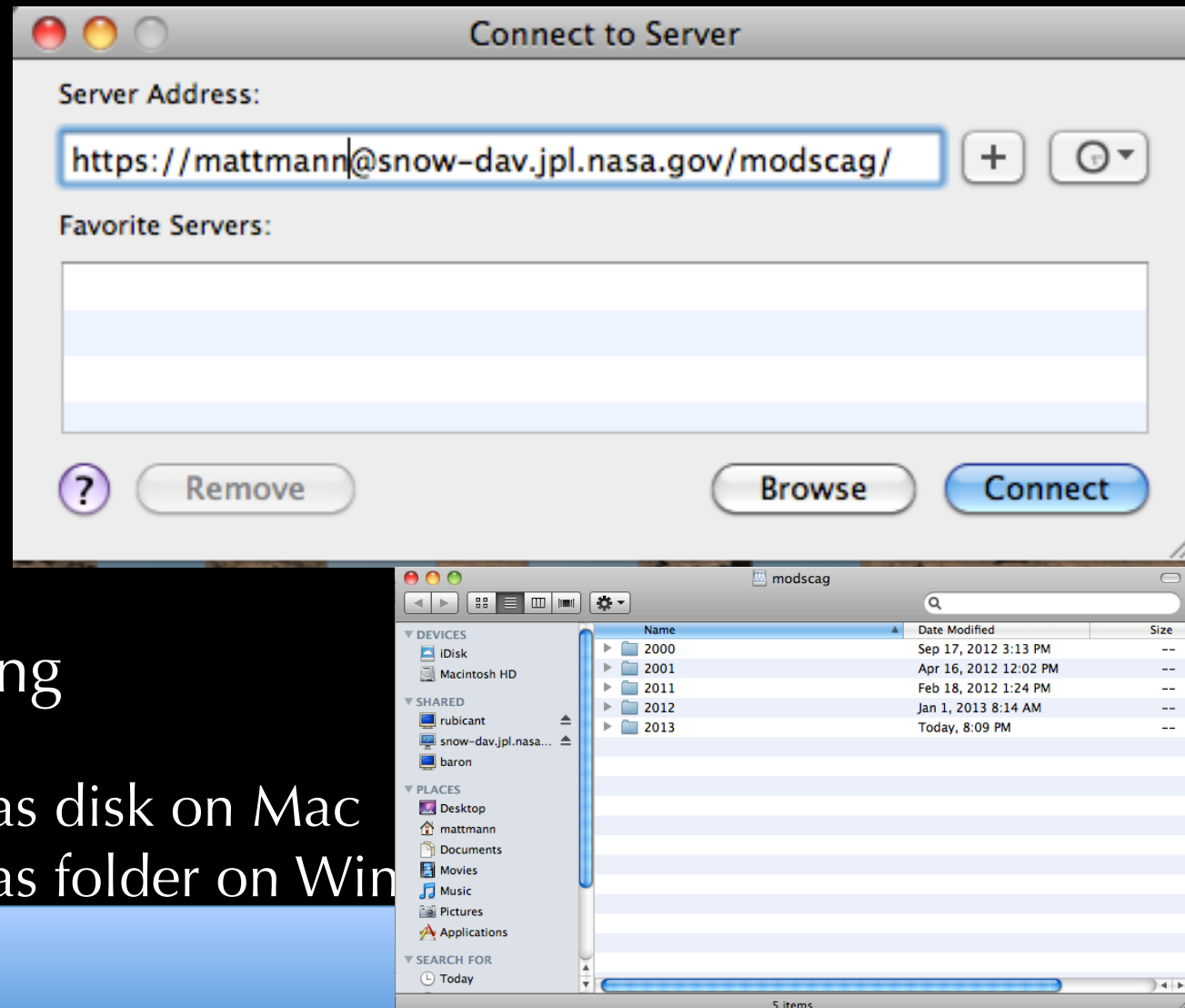
Product Metadata: MOD09GA.A2013034.h10v03.005.NRT.hdf

MetadataLanguage	en
DatasetTitle	MODIS/Terra Surface Reflectance Daily L2G Global 1km and 500m SIN Grid
ProductType	MOD09GANRT
MetadataStandardVersion	1.0
MetadataStandardName	ODT PCS
OrbitNumber	69847 69848 69849 69850
CAS.ProductReceivedTime	2013-02-03T20:04:43.510-08:00
WestBC	-159.99999995957
DatasetCharset	UTF-8



WebDAV Data Delivery

- Web-based Distributed Authoring and Versioning (WebDAV)
- Clients available on every major operating system
 - Can mount as disk on Mac
 - Can mount as folder on Win





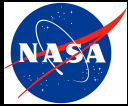
Data available on WebDAV

- Snow Covered Area
 - Historic pipeline and NRT
- Dust Radiative Forcing
 - Historic pipeline and NRT
- URLs and user accounts are provided to users after agreement with Dr. Painter



Collaborations and Users

- Funded work on NASA Water Resources, and on Airborne Snow Observatory demonstration
 - NOAA Colorado Basin River Forecast Center
 - California Department of Water Resources
 - Bureau of Reclamation
- Discussions ongoing with ESRI and Google Earth Engine
- Partnering with UCLA on WEBS
 - McKenzie Skiles
- NSIDC, Mary Jo Brodzkik & Marilyn Kamanski



Summary

- Snow Covered Area and Dust radiative forcing pipelines for NRT and historic processing
- Western Energy Balance of Snow data
- SNOWMAP GIS
- Data products available via multiple mediums
 - HTTP/Portal, WebDAV
- And multiple formats (CSV, JSON, GeoTIFF)



You're done!

- We hope you have had a great experience!
- *Feedback about course content – expect a survey from us it will be short and will help us make the course useful to YOU*
- Thank you!